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Training out the "a" effect and possibilites of its transferability

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Abstract

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G.R.B.
G.J.L.

INTRODUCTION

The effects of body tilt on the perception of vertical, and its relation to the perception of the degree of tilt of one's own body, has been studied since Aubert.

The "A" effect found by Aubert (1860) is the product of tilting a subject more than 60° laterally. Subjects will set an apparent vertical line tilted in the same direction as they are tilted. The "A" effect is basically a constant error of the judgement of vertical. Studies done using the "A" effect have shown it to be quite reliable and repeatable. No one really knows what causes the "A" effect.

> Aubert (1861) suggested that his effect was due to the subject underestimating the tilt of his head because of adaptation of the somaesthetic and vestibular senses. Helmholtz (1962) agreed with Aubert's interpretation. Nagel, on the other hand, disagreed. Lying on his side, he set a rod to the apparent vertical and found that it was in fact tilted in the same direction as his body (A-effect). In spite of this, his body felt as if it was tilted more than it was. He therefore dismissed Aubert's suggestion that the effect is due to underestimation of the tilt of the body.(3)

Bauermeister(1964) found similarities and differences in the deviation of apparent body position, as compared to the objective position of the body while tilted. The important similarity pertains to the reversal of the tendency of displacement for both apparent vertical and apparent body

position. It was found that positions of tilt and apparent body position deviated more in the direction of tilt than did the apparent vertical. Bauermeister found the subject was able to locate the stimulus object with respect to two spatial reference systems, (a) of external space, especially vertical and (b) reference system of one's own body tilt.

Bauermeister's study confirmed Nagel's findings of tending to exaggerate the displacement of the body from vertical. This is confirmed by the fact that when subjects were asked to set a line parallel to their bodies while tilted they set the line beyond the degree of body tilt in the same direction as tilt. There seems to be evidence (Nagel 1963; Vestibular Stimulation by Electrodes) that the vestibular organs are part of the stimulus needed to produce the "A" effect, but Mann (1951) and Fisher (1930) reported that the labyrinths are not necessary for the "A" effect. Bauermeister's study showed a relation between the task of setting a line to an apparent vertical position and setting it to appear parallel to the body axis, while the body is in a tilted position.

Bauermeister does not postulate a causal direction in the relationship. However, if the "A" effect is a function of overestimation of body tilt, then attempts to train judgement of body tilt should transfer significantly to the

judgement of vertical. This study was concerned with the possibilities of (1) reducing the "A" effect by direct training, (2) determining whether direct training of vertical judgements transfers to the setting of a line parallel to the body while the body is tilted, and (3) determining whether training subjects to set a line parallel to the body would transfer to setting a line vertical. The relationship among apparent body position and apparent vertical can be further revealed by the answers to these questions.

PROCEDURE

The subject was first given an eye patch, which was placed over the left eye. He was then positioned on his right side, tilted 82°, in a tilting chair facing a projector screen. The trunk-neck axis of the body was aligned. The room was completely darkened, thus there was no visible frame of reference. An adjustable luminous line was presented on a large diffuse screen with no borders to reflect light. The screen was 10 feet from the subject and about 20 feet from the projector. The line was approximately 12 inches long.

Our subjects were aligned slightly off axis of the projector, and screen, to avoid blocking the light.

With alternate trials the line was presented to the

subject from two directions so a non-biased judgement would occur. From one direction the line was rotated clockwise and from the other the line was rotated counter-clockwise. Each subject was told by the experimenter he was going to be presented a luminous line. The following verbal instructions were given: "For the first three trials you are to say, 'now,' when the line appears vertical; for the second three judgements you are to say, 'now,' when the line appears parallel to your body. After each trial you are to close your eyes and lift your head up from the tilted position--to a position that feels vertical to you. Upon instruction, put your head back into the rest and open your right eye and proceed with the next judgement."

Training Instructions:

For training, the 12 subjects were assigned to two equal groups of six. Half the subjects were trained to set the line vertical, and half were trained to set the line parallel to the body.

The "vertical" group received the instructions below. Our "parallel" group received identical instructions except the word "parallel" was used in place of the word "vertical".

"You are going to be presented with a luminous line while lying with your head in the headrest. You are to say 'now' when the line appears vertical (parallel). I will

then show you the line which is actually vertical." The subject was then properly positioned in the headrest and chair.

"Between each trial close your eyes and lift your head from the headrest, to a position where your head feels close to vertical. We will repeat this procedure fifteen times."

Post Test Instructions:

If a subject was trained on vertical lines, he was tested first on three estimations of lines parallel to the body, followed by three vertical judgements. If he was trained on lines parallel to the body, he was first tested on estimation of vertical, followed by three estimations parallel to the body. The instructions were the same as those used in the pre-test.

The following is an explanation of the statistical treatment of the data. It shows our sign convention and explains our treatment of typical and atypical conditions encountered.

Atypical Conditions:

1. Wrong Direction:

> Any subject who became more accurate on the training task but changed in the opposite direction on the transfer task, did not show transfer of training. In the column marked "percent of transfer" the subject would be scored zero.

2. Correct Transfer beyond Training Amount:

Any subject who showed training and transfer in the same direction as training but transfer exceeded training; this is not true training since, operationally, the change on the training task defines the extent of training and therefore of transfer. This rates a transfer score of 100%

3. No Training Effect:

When no training effect occurs, changes in the transfer task cannot be called transfer. This rates a transfer score of zero.

Typical Data:

1. Signs of Pre-Test (A effect+)

Subtract the before measure from the after measure; the difference is equal to the amount of change, or reduction of the A effect. This is a plus (+).

2. Signs of Pre-Testing of Setting a Line Parallel to the Body:

Subtract the before measure from the after measure; set up data so that a plus equals a reduction in overestimation and underestimation of parallel to the body. In other words, a change in estimation toward being parallel with the body.

For both groups the combined mean "A" effect was 12.46°. The combined mean error in estimating body position was 3.00° overestimation. The group trained on vertical judgements showed a 42.7% transfer of the training. The second group, trained on body parallel, showed a transfer of 15.83%. Considering improvement due to training, the group

trained on "vertical" improved 63.45%. The group trained on "parallel" 'improved' 100%. This must be considered a change but not an improvement since the average error was only $+0.116^{o}$. Nonetheless, three of the subjects in the group made substantial improvement following training. The group data does not reveal this, because not all subjects improved, and because the initial errors were in opposite directions, thus cancelling out in the mean.

	1	2	3	4	5	6	7
	Train			Transfer			
1st Set Subjects	Pre	Post	Difference	Pre	Post	Difference	% Transfer
S. S.	26°	3.3°	+22.7°	97.7°	95°	2.7°	8.4%
G. V.	14.3	11	+3.3	80.3	79.7	0.6	18.2%
D. H.	3	-2.0	+5.0	80.3	75	5.3	100%
G. B.	19.25	8 1/2	+10.75	104	94	10	92.6%
J. D.	9 2/3	9 2/3	0	83 2/3	80 2/3	2	0
B. P.	14	1 1/3	+12.67	81 2/3	77	4 2/3	37%
$\bar{x}$	14.36°		9.07°	5.88°		4.22°	42.7%

Mean A effect = +12.46°. This is an average of column 1 in first set of six subjects and column 4 in second set of six subjects.

Mean Parallel to body = +3.00°. This is an average of column 4 in first set of six subjects and column 1 in second set of six subjects.

	1	2	3	4	5	6	7
	Train ⊢—			Transfer ⊥			
2nd Set Subjects	Pre	Post	Difference	Pre	Post	Difference	% Transfer
J.R.D.	80°	78.3°	+1.7°	1.7°	-1.3°	3°	0
C. L.	73.3	79.7	-6.4	18.7	4.3	+14.3	0
G. L.	92	81 2/3	+10 1/3	13 1/3	11 2/3	1 2/3	+15.5%
S. F.	79	78 2/3	+ 1/3	12	4	8	0
B. M.	86 2/3	79	+7 2/3	11 2/3	8 1/3	3 1/3	75%
D. R.	81 2/3	81 2/3	+ 1/3	6	7	-1	0
$\bar{x}$	+0.116°		+2.29°	10.56°		+4.88°	15.83%

Mean A effect = +12.46°. This is an average of column 1 in first set of six subjects and column 4 in second set of six subjects.

Mean Parallel to body = +3.00°. This is an average of column 4 in first set of six subjects and column 1 in second set of six subjects.

Reviewing individuals we note the following:

S.#1 J.R.D. underestimated body tilt to start with; after training he underestimated it 1.7° more. Thus, in terms of accuracy, he got worse, but the change was toward zero, so it was scored as plus. His change transferred but it could hardly be caused by training. You couldn't very well say his "A" effect was due to over-estimating tilt in the first place.

S.#2 C. L. underestimated by 8.7° to start with. After training he is off only 2.3°, an improvement of 6.4°. But the direction was away from zero. Thus on the transfer test his "A" effect should have been worse, but it wasn't. There was zero transfer.

S.#3 G. L. overestimated by 10° and improved to essentially perfect judgements with training. Training was perfect, and it transferred only slightly.

S.#4 S. F. underestimated at first and changed hardly at all (1/3°). We scored it zero due to the fact that his training effect was about zero. There was essentially nothing to transfer.

S.#5 B. M. overestimated by 4 2/3° and actually overshot the mark of training by 3°. He goes in the same class as G. L. above.

S.#6 D. R. was essentially accurate at the start; didn't change much after training. Same as S. F.

DISCUSSION

In evaluating our data, several observations are possible. For setting the line to apparent vertical, when tilted 82°, there is a constant and prominent effect shown. This effect, the "A" effect, was 12.46° in the direction of

body tilt. The deviation shown is within limits of other studies reviewed on the "A" effect.

The estimation of body tilt, demonstrated by setting a line parallel to the body-neck axis, also produced a constant deviation. It showed an overestimation of only $\bar{x} = 3.0^{\circ}$. This does not agree with Bauermeister's data for body tilts of 82°. He reported there was an overestimation of body tilt at all angles. Our data show only a small deviation. Bauermeister reported the "A effect" is always less than the overestimation of body position. We do not confirm this. Instead our "A" effect is larger than the amount of overestimation of body tilt. Since our "A" effect agrees in magnitude with many previous reports we feel our procedures were reliable.

This suggests that overestimation of body position is not an explanation of the "A" effect, contrary to Bauermeister who believes that overestimation of tilt was an important factor in the "A" effect.[1]

The training out of the "A" effect has never been reported in the literature. Our studies were designed to

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[1] Regarding estimation of body tilt, many feel the "E" effect is a piggyback rider having nothing to do with estimation of body tilt. This could certainly be true. Perhaps the "E" effect is not as reliable as people have been led to believe. A slight foray into research on the "E" effect showed greater difficulty in eliciting it than it would lead one to believe.

see if such effects are trainable, and if trainable could a supposed correlate of the effect undergo transfer of training. The "A" effect was chosen because of its large magnitude and reliability. Our data clearly show one can reduce the "A" effect by training. The training transferred by approximately 42% to judgements of body position. Material in the literature did not lead us to believe this possible. The reverse transfer was much less. Training on judgements of body position (parallel to body) transferred 15.83% to the vertical judgements. However, since there was far less error in estimating body tilt, even complete transfer would not reduce the "A" effect significantly. It appeared that the best way to train the "A" effect is directly.

Throughout our procedures we did not use an untrained control group. Even so, we believe our statistical studies did not need to rely on one. We could have a group which went through before and after measurement, spent the same time in the chair getting up and down, but made no visual judgements. From this we cannot evaluate the reliability of the data over a time span equal to the length of the training session. Therefore, we used statistical means to verify our data, measuring transfer as a percent of training effect. Changes in the transfer task were measured as 0% for subjects who trained in the wrong direction and

100% transfer for subjects who exceeded their training effect, but changed to the same direction as the training. These considerations should adequately substantiate our belief of the training and its transfer.

A followup study of overestimation of body tilt and amount of "A" effect at varying degrees of body tilt is needed. This should help to show that the "A" effect is not dependent only on overestimation of body tilt.

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APPENDIX I

In taking the data, a measurement of the amount of tilt of the vertical line was done with the aid of a protractor attached to the projector. Ninety degrees represented a vertical setting. One hundred seventy two degrees represented a setting of parallel to the adjusted position of the subjects. If the subject set the line past parallel opposite the direction of body tilt the readings were less than ninety and readings more than ninety represented setting the line in the direction of body tilt. Setting a line more than 172° meant setting the line beyond the amount of body tilt. Less than 172° represented setting the line less than the degree of body tilt.

SUBJECT 1

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
116	104	95
116	104	90
116	90	95
116	90	93.3
	92	
	93	
body tilt 80° set line parallel	89	test set line parallel
	90	
	93	
185	89	185
188	94	185
190	92	185
187.7	93	185
	89	

SUBJECT 2

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
98	113	105
108	92	105
107	96	93
104.3	95	101
	90	
	93	
	96	
body tilt 80° set line parallel	97	test set line parallel
	92	
	94	
166	93	172
171	92	167
174	92	170
170.3	90	169.7
	94	

SUBJECT 3

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
88	90	88
98	88	88
93	90	88
93	93	88
	90	
	93	
	95	
body tilt 80° set line parallel	85	test set line parallel
	95	
	95	
169	93	160
170	90	166
172	92	170
	93	
170.3	89	165

SUBJECT 4

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
108	110	108
114	112	101
103	108	93
112	87	92
109.25	85	98.5
	86	
	90	
body tilt 80° set line parallel	85	test set line parallel
	103	
	90	
193	90	187
195	88	180
195	90	185
	90	
194	87	184

SUBJECT 5

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
100	110	99
98	95	100
101	93	100
99 2/3	91	99 2/3
	93	
	95	
	94	
	92	
	94	
	92	
	90	
	90	
	92	
	90	
	93	

body tilt 80° set line parallel	test set line parallel
173	171
175	170
173	171
173 2/3	170 2/3

SUBJECT 6

body tilt 80° set line vertical	train with feedback set line vertical	tilt 80° test set line vertical
108	105	90
105	95	92
99	95	92
104	95	91 1/3
	100	
	98	
	100	
	97	
	92	
	93	
	93	
	90	
	94	
	90	
	92	

body tilt 80° set line parallel	test set line parallel
162	167
178	167
175	167
171 2/3	167

SUBJECT 1

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
96	153	93
90	163	90
89	154	83
91.7	155	88.7
	170	
	170	
	167	
body tilt 80° set line parallel	171	test set line parallel
	170	
	170	
172	170	161
168	171	169
170	168	175
170	170	163.3

SUBJECT 2

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
110	162	95
105	172	93
110	172	95
108.7	172	94 1/3
	173	
	175	
body tilt 80° set line parallel	168	test set line parallel
	175	
	172	
160	176	174
160	172	166
170	172	169
163.3	175	169.7
	171	

SUBJECT 3

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
102	182	110
100	175	98
108	174	95
103 1/3	172	101 2/3
	172	
	172	
	172	
body tilt 80° set line parallel	175	test set line parallel
	176	
	172	
182	172	168
182	172	175
182	170	172
182	171	171 2/3
	172	

SUBJECT 4

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
103	170	95
105	171	94
98	171	93
103	167	94
	168	
	168	
	168	
	170	
body tilt 80° set line parallel	167	test set line parallel
	165	
	168	
170	168	170
168	168	170
168	169	167
169	168	168 2/3

SUBJECT 5

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
100	170	98
98	172	97
105	170	100
101 2/3	172	98 1/3
	173	
	171	
body tilt 80° set line parallel	173	test set line parallel
	171	
	170	
175	170	171
175	172	168
180	170	168
176 2/3	169	169
	172	

SUBJECT 6

body tilt 80° set line vertical	train with feedback set line parallel	tilt 80° test set line vertical
98	165	102
93	175	94
96	173	94
96 6°A	172	97 7°A
	168	
	165	
	170	
	168	
	175	
body tilt 80° set line parallel	172	test set line parallel
	176	
	176	
165	172	174
180	175	165
170	172	172
171 2/3	172	171 1/3

APPENDIX II

The original intent of this thesis was to use the "E" effect in similar training procedures. We were unable to get a statistical significent "E" effect produced in our pretesting. If the "E" effect is present at 30°, it is of a small magnitude. The "A" effect was then substituted for the "E" effect; it was found present in almost every subject tested. The factors behind the "E" effect are not known.

APPENDIX III

BASIS OF PROCEDURE

1. Before Measure

    a. judge vertical line body tilted 82^{o}

    b. set line parallel to body, same tilt

2. Training

    a. subjects are divided into two equal groups:

        (1) group one is trained to judge vertical; reinforcement is given on each judgement.

        (2) group two is trained to judge body-parallel; feedback given on each judgement.

    b. training was 15 trials of setting the line, receiving feedback on each judgement.

3. Testing

    a. group one is first tested on body parallel judgement, then tested on vertical judgement.

    b. group two is first tested on vertical judgement, then tested on body parallel judgement.